REMARKS

Applicants gratefully acknowledge Examiner Do for taking time from his busy schedule to conduct a telephone interview on March 14, 2007, with co-inventor Dr. Gustavson and Applicants' representative F. Cooperrider. It is believed that this interview was very beneficial because it allowed the co-inventor to explain the significance of the present invention and its distinctions from the cited prior art. Examiner Do seemed to agree that there were indeed differences but was unwilling to agree that the original claims adequately articulated these differences.

Claims 1-8, 10-21, 23, 24, and 26-28 are all the claims presently pending in the application. Various claims have been amended to more particularly define the invention, in view of the discussion during the above-mentioned telephone interview with Examiner Do and the Examiner's helpful suggestions. Claims 9, 22, and 25 have been canceled, and claims 26-28 have been added to claim additional features of the invention.

It is noted that the claim amendments are made only for more particularly pointing out the invention, and <u>not</u> for distinguishing the invention over the prior art, narrowing the claims or for any statutory requirements of patentability. Further, Applicant specifically states that no amendment to any claim herein should be construed as a disclaimer of any interest in or right to an equivalent of any element or feature of the amended claims.

Claims 1-25 stand rejected under 35 U.S.C. § 101 as allegedly directed to non-statutory subject matter. Claims 1-3, 7-17, 21-23, and 25 stand rejected under 35 U.S.C. § 102(a) as anticipated by U.S. Patent No. 6,601,080 to Garg. Claims 4-6, 18-20, and 24 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Garg, further in view of non-patent literature by Philip Alpatov, et al.

These rejections are respectfully traversed in the following discussion.

I. THE CLAIMED INVENTION

As exemplarily defined in independent claim 1, the claimed invention is directed to a method to at least one of reduce a memory space requirement and to increase a processing efficiency in a computerized method of linear algebra processing. A hybrid full-packed data structure is provided for processing data of a triangular matrix by one or more dense linear algebra (DLA) matrix subroutines designed to process matrix data in a full format, as modified to process matrix data using the hybrid full-packed data structure. The hybrid full-packed data

structure provides a rectangular full format data structure for the entirety of the triangular matrix data.

As explained during the above-mentioned telephone interview and on lines 9-16 of page 10 of the specification, the conventional dense linear algebra (DLA) data structures for triangular matrix data subroutines will either provide compact data storage along with slow processing speed or, alternatively, will provide faster processing speed but increased storage requirement.

In contrast, the present invention provides a method so that both compact storage and the faster processing speed are available. That is, the hybrid full-packed data structure taught by the present invention provides a full format storage of triangular matrix data that can be processed by the faster full-format subroutines, as modified to process this new rectangular data structure.

II. THE 35 USC §101 REJECTION

Claims 1-25 stand rejected under 35 U.S.C. §101. As best understood, the Examiner considers that all claims "... merely disclose steps of converting and manipulating data format in [a] matrix without [regard] to any particular practical application or tangible result." The Examiner also considers that claims 15-17 are directed to "signal medium" and, therefore, non statutory.

Applicants respectfully disagree.

First relative to claims 15-17, Applicants submit that these claims are clearly addressed to "[a] signal bearing medium tangibly embodying a program of machine-readable instructions executable by a digital processing apparatus ....." Such claims are often referred to as "Beauregard claims", after *In re Beauregard*, 53 F.3d 1583 (Fed. Cir., 1995), wherein the USPTO Commissioner conceded that such claims are indeed statutory subject matter. Examiner Do might want to read this case holding, since it is only three paragraphs in length and might want to check out the resultant patent, US Patent No. 5,710,578 to Beauregard, et al., issued on January 20,1998.

Relative to claims 10-14, these claims are directed to an apparatus and are, therefore, clearly directed to the statutory subject matter of a machine.

Relative to claim 23, this claim is clearly directed to a data structure in the context of a computer program, rather than a disembodied data structure in the abstract.

Relative to the method claims, as discussed during the telephone interview and

particularly described in amended independent claim 1, the present invention does indeed have the prerequisite practical application and tangible result (wherein "tangible" means "real-world") because it permits a reduction in memory space for the data and an improvement in calculating the matrix operation.

Therefore, the present invention is not merely manipulating data in the abstract nor even claiming the processing of the matrix mathematical operation in the abstract. Rather, as explained during the telephone interview, the present invention solves a long standing dense linear algebra problem of having two data structures (full and packed) for triangular (i.e., triangular or symmetric/Hermitian) matrices by eliminating the packed data structure, as explained on page 10 of the specification. The packed format uses half the storage but performs one to a hundred times slower than matrix processing algorithms written for the full format, whereas the full format uses twice the storage of packed and performs better or the same.

The present invention converts the packed or full data structure of symmetric or Hermitian/triangular matrix data into a hybrid full data structure (e.g., different from the standard full data structure). This hybrid full data structure saves half the memory storage compared to the full matrix data format and can be used with the faster full format processing, as modified to accommodate this hybrid full format.

The independent claims have been amended in an attempt to find wording more acceptable to the Examiner.

In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw this rejection.

III. THE PRIOR ART REJECTIONS

The Examiner alleges that Garg teaches the claimed invention defined by claims 1-3, 7-17, 21-23, and 25 and, when modified by Philip Alpatov *et al.*, renders obvious claims 4-6, 18-20, and 24.

Applicants respectfully disagree.

A key feature of the hybrid full-packed data structure of the present invention is that it produces a minimum storage representation of a triangular or symmetric/Hermitian matrix that is in standard Fortran or C storage format. (It is noted that "triangular" is generic and means both triangular and symmetric/Hermitian matrices.) Hence this format can be used by many Dense Linear Algebra (DLA) algorithms that operate on symmetric/ Hermitian and/or

triangular matrices. In fact, as explained during the above-mentioned interview, the present invention can be used in the Garg patent when Garg uses its 2-D representation of the triangular parts of its super-nodes.

Garg describes a method for efficiently solving a system of equations involving a sparse positive definite symmetric matrix, using a supernodal approach to perform a CMOD operation on either a 1-D trapezoidal sparse representation or a 2-D representation of the supernode. As explained in the above-mentioned telephone interview, the present invention could be used advantageously in Garg both as a 2D storage reduction method, as well as modified subroutines to improve its efficiency. The domain of the present invention is DLA symmetric or Hermitian and/or triangular algorithms, whereas the domain in Garg is sparse linear algebra for only Cholesky factorization.

That is, the hybrid full-packed data structure of the present invention replaces standard dense full format or standard dense packed format of a triangular or symmetric/Hermitian matrix. The hybrid full-packed data structure of Garg refers to 1-D sparse and 2-D sparse representation of a trapezoidal supernode.

In the rejection of the independent claims, the Examiner points to Figures 5 and 10 of Garg, along with the description at lines 28-51 of column 5 and line 57 of column 11 to line 15 of column 12. However, Applicants submit that it is clear that neither of these two figures nor the cited description shows or describes a symmetric/triangular matrix whose <u>data in the entirety</u> is converted into the rectangular data structure shown in Figure 3 of the present application.

Along the same lines, Fig. 9 of Garg and Col 12, lines 40 to 65, discuss three instances of the representation of super-node. Fig 9B shows a dense 2-D representation, lines 47 to 49. One can clearly see that each triangle in Fig. 9B is depicted as a full square, even though because of symmetry, only the lower triangle needs to be stored. Fig. 9C, lines 49 to 65 is perhaps more telling. There are three super-nodes, the middle being 1-D and the other two being 2-D. Again, Garg depicts clearly a full square for his 2-D representations when clearly only the lower triangular part is required as Garg show for his 1-D representation. So, Applicants submit that Garg cannot be teaching our invention because Garg has failed to use it when he clearly could have.

In order to satisfy the plain meaning of the invention of the independent claims, the Examiner would have to show a prior art example of converting the <u>entirety</u> of data of a triangular matrix into a rectangular format. As shown in Figure 3, in the example, the square

portion of the data is determined and then the tail of the triangular matrix data is fitted to the upper portion (although, the same effect of creating a rectangle would occur if the upper triangular data portion were to be fitted to the lower, tail portion). There is no similar triangular matrix conversion shown in Garg in which the <u>entire triangular matrix data</u> is converted into a rectangular data structure that can then be used in full-format linear algebra subroutines, such that the Examiner can point to a square portion and two triangular portions <u>of an original triangular matrix</u> that has been relocated to form a rectangular block of matrix data.

The Examiner relies upon secondary reference Alpatov, *et. al.* for reasons unrelated to this aspect of the present invention, so that Alpatov does not overcome this basic deficiency of Garg.

Hence, turning to the clear language of the claims, in Garg there is no teaching or suggestion of: "... wherein said hybrid full-packed data structure provides a rectangular full format data structure for <u>an entirety of said triangular matrix data</u> ....", as required by claim 1. The remaining independent claims have similar language.

Therefore, Applicants submit that the present invention is clearly patentable over Garg, even if modified by Alpatov, *et al.*

Relative to the rejection for claim 3, wherein the Examiner points to Fig. 7 of Garg, as mentioned in the above-mentioned telephone interview, the present invention can be used as a subroutine to represent the standard full format triangle at col_i of L (order 6; requires 36 locations to store 21 elements) of Garg. In this case, the present invention would represent col_i of L by LHFP T and LHFP S1 which requires 12 plus 9 = 21 storage locations.

LHFP = T	LHFP = S1
33 00 10 20	30 31 32
43 44 11 21	40 41 42
53 54 55 22	50 51 52

The above data can be represented by a rectangle of size 3 by 7 = 21 elements. Also, the present invention can be used as a subroutine to represent the standard full format triangle at col_k of L (order 7; requires 49 locations to store 28 elements) of Garg. In this case, the present invention would represent col_k of L by LHFP T and LHFP S1 which requires 16 plus 12 = 28 storage locations.

LHFP = T	LHFP = S1
33 00 10 20	30 31 32
43 44 11 21	40 41 42
53 54 55 22	50 51 52
63 64 65 66	60 61 62

So, a total or 15 + 21 = 36 storage locations are saved by applying the present invention to Garg for this example therein. For these changes, the performance of the CMOD operation will be the same or slightly improved. It is important to realize that Garg is wasting storage and slightly degrading performance by not using the data structure of the present invention as a subroutine.

Relative to claim 7, Applicants respectfully submit that the Examiner is incorrect, since B has size 7 by 6, and L at i is order 6 and uses 36 locations to store 21 elements.

Similarly, relative to claim 8, B has size 7 by 6, and L at i is order 6 and uses 36 locations to store 21 elements. The upper part of L at i is equal by symmetry to L. This upper part of L is NOT used by Garg.

Relative to claim 9, Garg neither uses hybrid full packed data structure nor does Garg use standard dense packed format. Applicants, therefore, respectfully request that Examiner Do explain how he concludes his assertion based on using Figures 5 and 10 of Garg.

Relative to the modification of primary reference Garg by secondary reference Alpatov, et. al., the present invention is not concerned with Parallel Linear Algebra Libraries. Rather, it is concerned with serial libraries (eg., LAPACK).

Moreover, it is noted that co-inventor Gunnels is a co-author of Alpatov, et. al., and submits that he fully understands his own paper and that co-inventor Gunnels does not concur with Examiner Do's position on this secondary reference.

Claims remaining that have not been specifically discussed are either dependent upon the independent claim 1 or an independent claim with similar wording or have an argument similar to one of the claims specifically discussed above.

Therefore, Applicant submits that there are elements of the claimed invention that are not taught or suggest by Garg, even if modified by Alpatov, et. al., and the Examiner is respectfully requested to withdraw these rejections.

Further, Applicants respectfully submit that the Examiner can point to no motivation or suggesting in the references to urge the combination as alleged by the Examiner. Indeed, Applicants respectfully submit that the Examiner supports the combination by merely stating that the combination would have been obvious "... because it would enable to overcome the

complexity of performing parallel computations." As pointed out above, PLAPACK is not equivalent to LAPACK.

Moreover, Applicants respectively think that the rationale of Examiner Do for this combination would be considered merely a circular argument wherein the motivation to modify the primary reference is merely stated as the result to be achieved if the combination were to be made. Applicants submit that there is no suggestion in either Garg or Alpatov, et. al. for the urged modification to Garg.

IV. FORMAL MATTERS AND CONCLUSION

The specification been corrected to update the co-pending applications listed at the beginning of the disclosure.

In view of the foregoing, Applicants submit that claims 1-8, 10-21, 23, 24, and 26-28, all the claims presently pending in the application, are patentably distinct over the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

The Commissioner is hereby authorized to charge any deficiency in fees or to credit any overpayment in fees to Assignee's Deposit Account No. 50-0510.

Respectfully Submitted,

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